

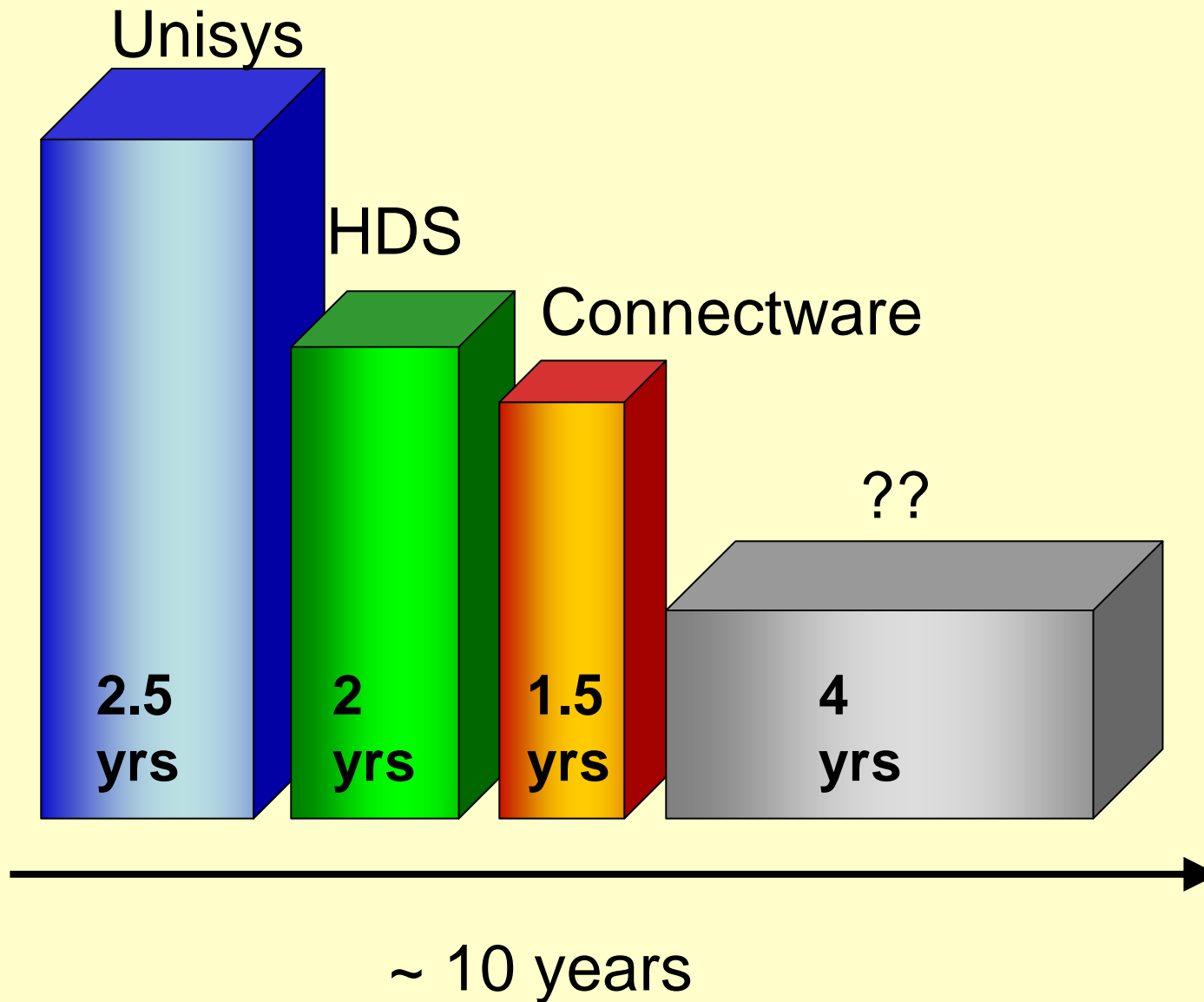
The Travails of an OO Design

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Lessons Learned

- Good designs are valuable
- Industrial SE practices are primitive
- Performance and design are compatible
- Profilers are limited
- Refactoring a good design is cheap
- The STL creates performance problems

Prior Experience



Management Worldview

- Minimize programmer salaries
- Assign programmers to code permanently
- Priorities are schedule, features, quality
- Design is a waste of time
- No need for metrics
- Search for magic bullet technology

Resulting Software

- Called an OO design, but...
- Little inheritance
- Uneven decomposition
 - Functions with >1000 LOC
 - 8 levels of nested control structures
 - Data format details not encapsulated
 - Myth: decomposition leads to slow code
- Little design documentation

Consequences

- The code was difficult to modify
 - A data format change took 6 months
 - Still working out the bugs one year later
- Difficult to reuse code
- Programmers burnt out
- Requests for enhancements turned away

Project Goals

- Reduce latency of maps over internet
- Convince management to support design
- Debunk performance myth
- Create a maintainable code-base

Project Approach

- Reengineer the system
- Use UML techniques
- Drive design with carto. requirements
- Team of 2 core designers (including myself)
- Consulted with about 5 domain experts
- Implemented in C++ with reference counting

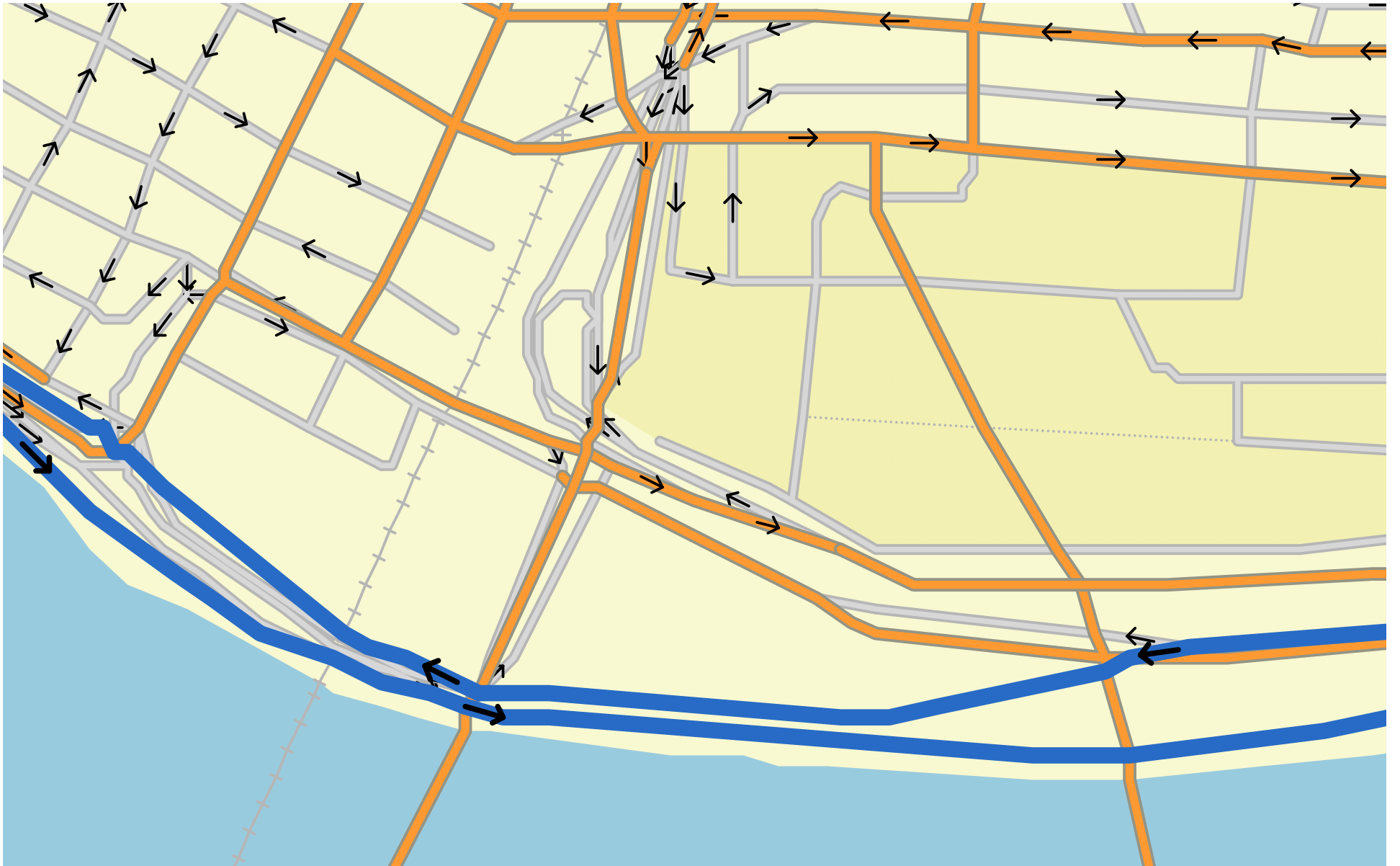
Research Objectives

- Test case for applying UML
- Evaluate the performance of OO designs
 - Remove bottlenecks
- Compare latency of server-side and client-side mapping systems

Features: Polygons



Features: Lines



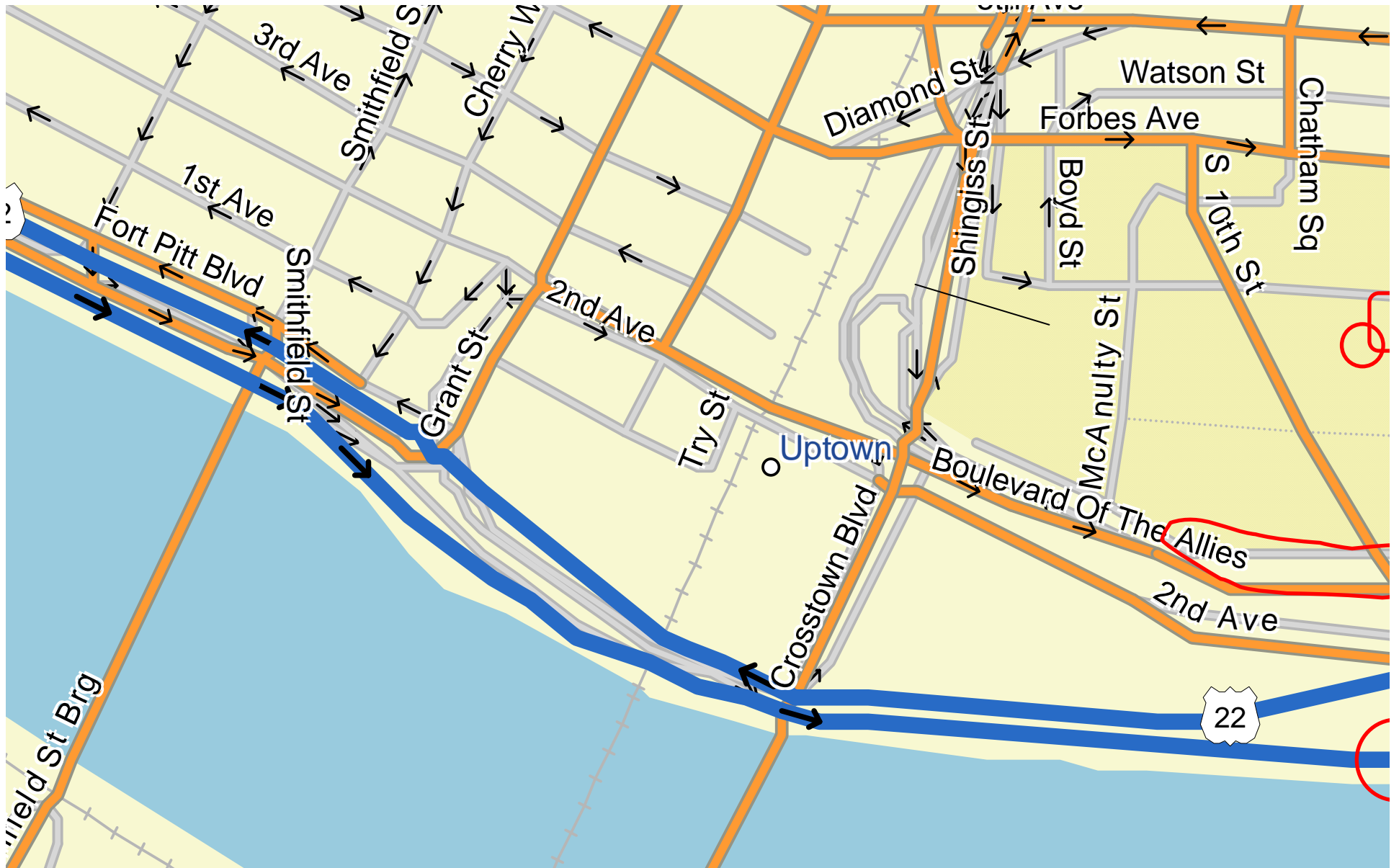
Features: Points



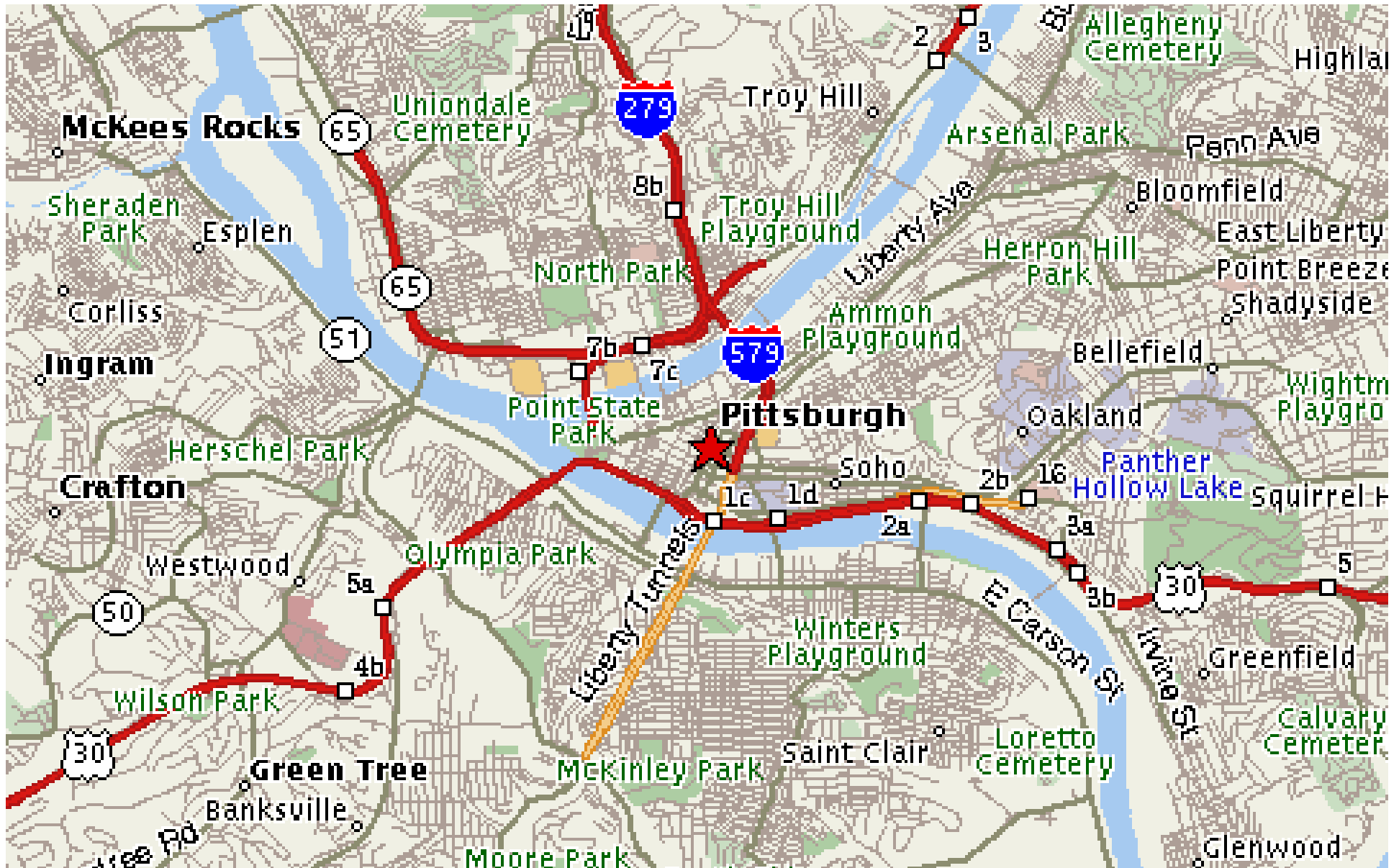
Labels



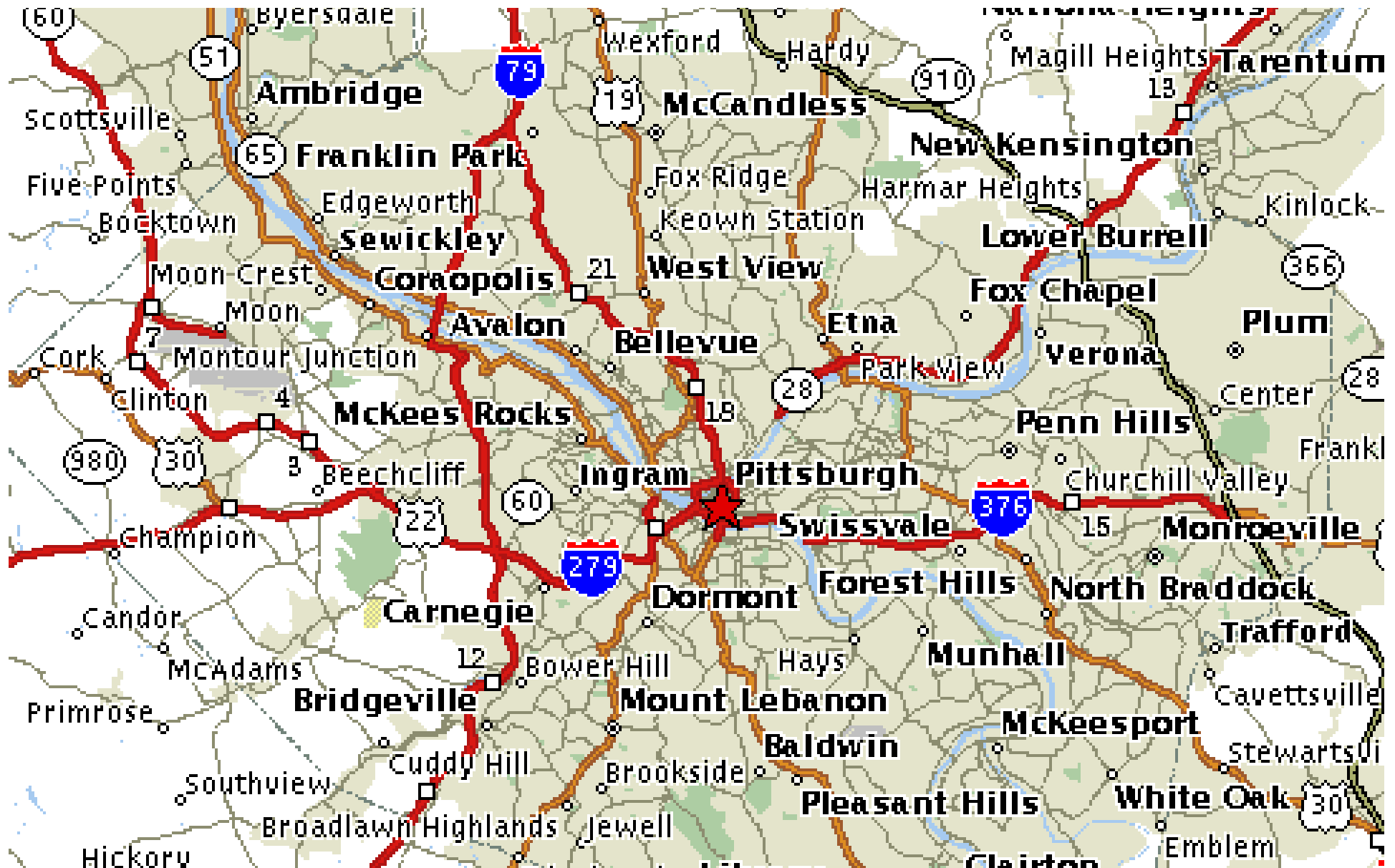
Label Placement



Reuse and Scaling



Feature Reduction



Multiple Layers

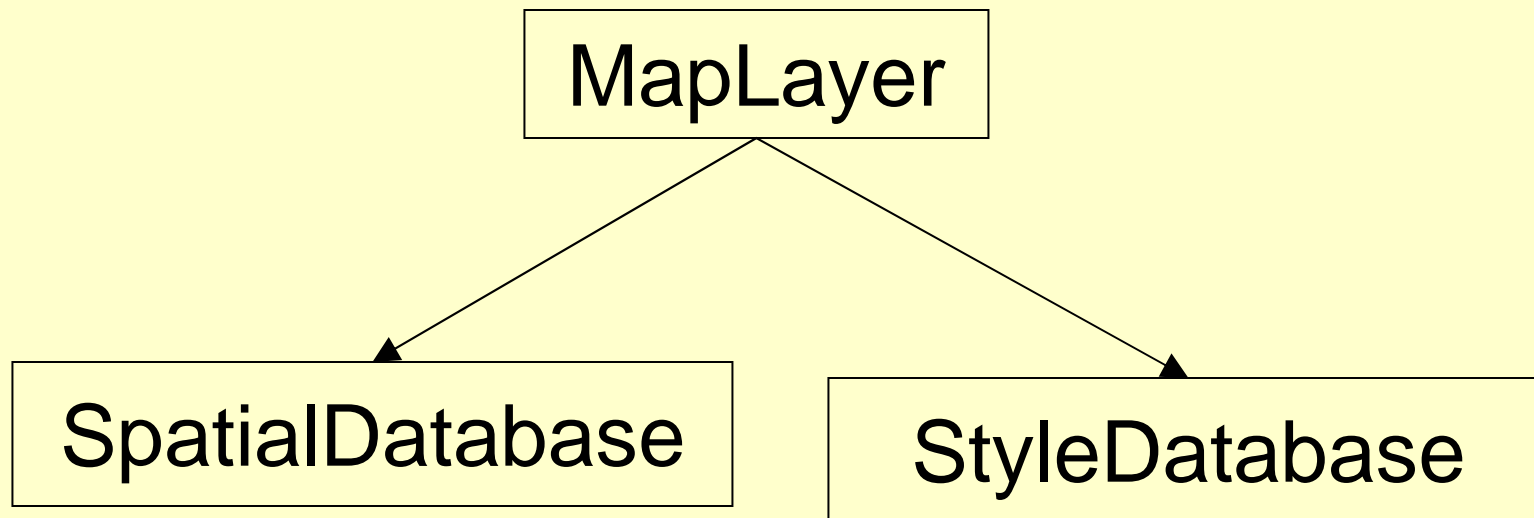


Databases

- SpatialDatabase – Holds permanent data
 - Name, shape, etc.
 - Indexed by (feature type, geographic area)
 - Must clip large objects to a reasonable size
- StyleDatabase – Formatting information
 - Colors, widths, etc.
 - Draw order
 - When to drop features
 - LabelPlacement priority

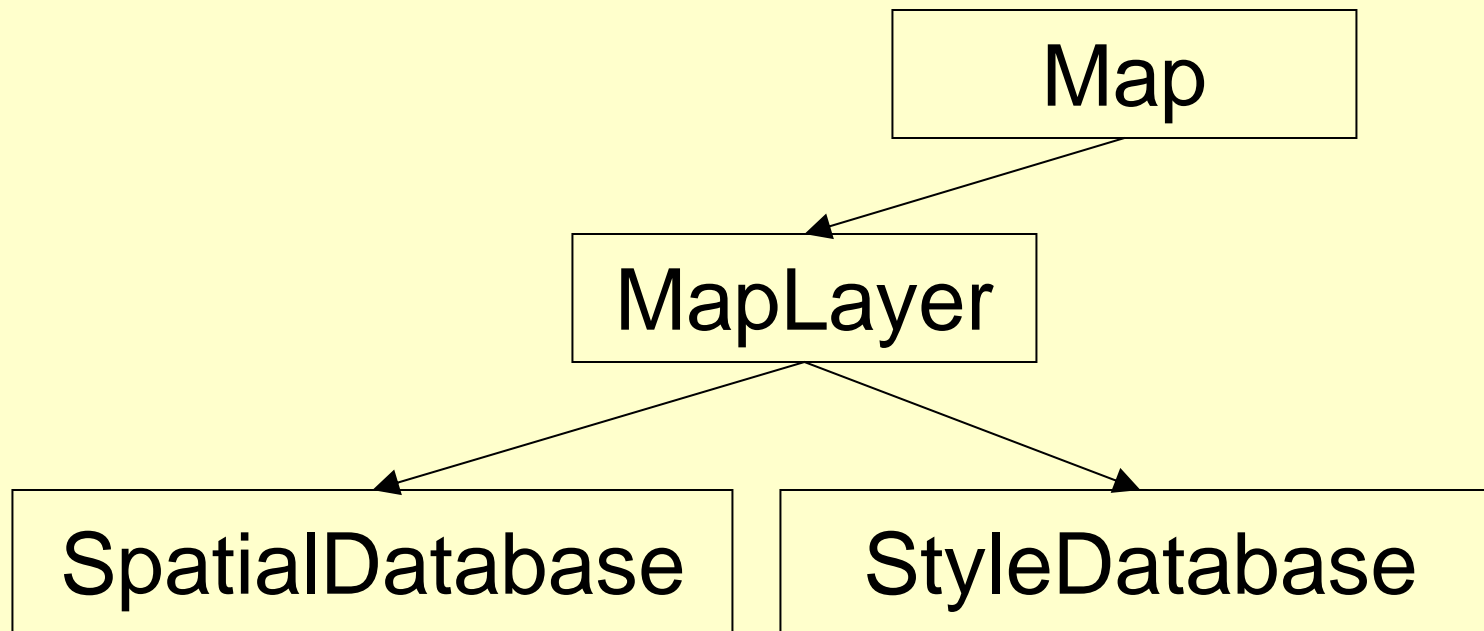
Layers

- Combines Data from SpatialDatabase and StyleDatabase to form a complete layer



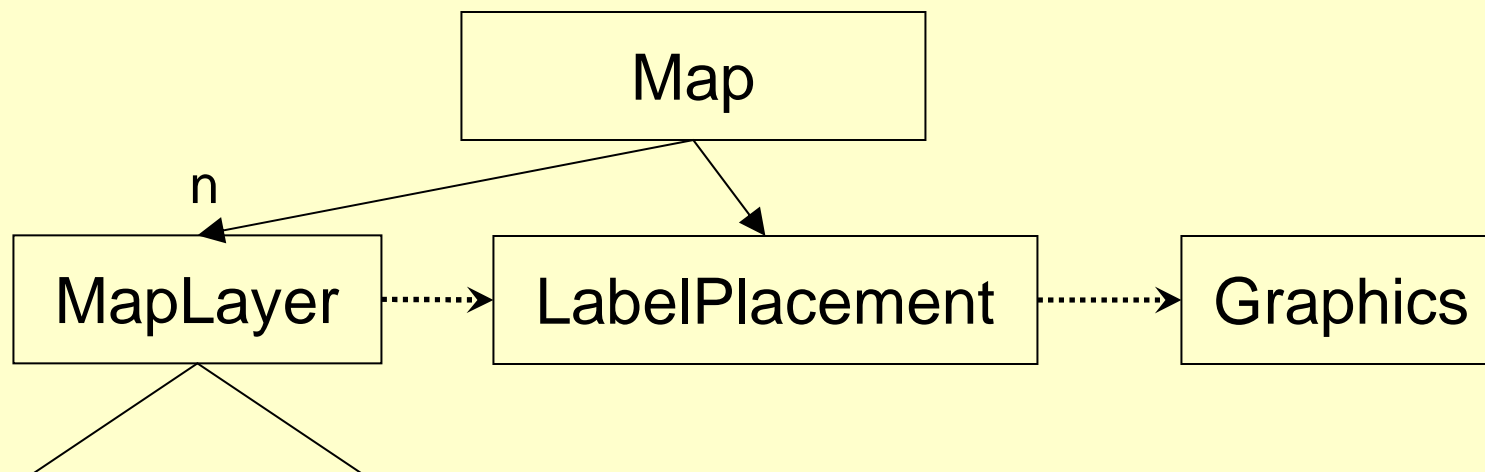
Map

- Combines multiple layers
- Provides simple interface to programmers



LabelPlacement

- Intercept and buffer points
- Draw other features immediately
- Store feature locations
- Calculate acceptable label positions
- Place highest priority first



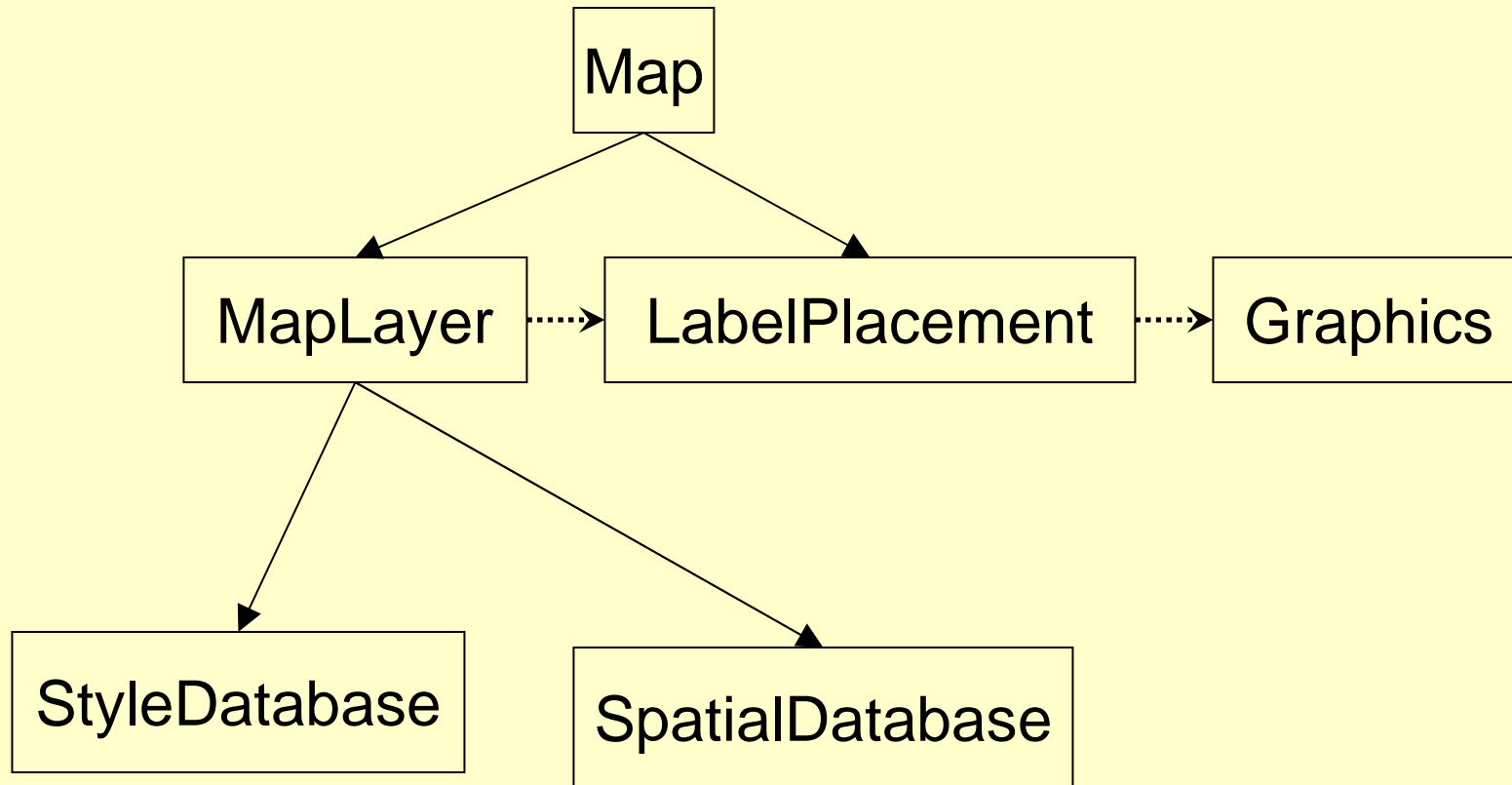
Extensibility

- Problem: Both databases will be extended with new fields
 - Classes that don't understand just pass through
- Solution: a Feature class to hold the data
 - Examples: points, lines, and polygons with formatting
 - Has name for the label
 - Some number of points
- Feature objects are passed between classes

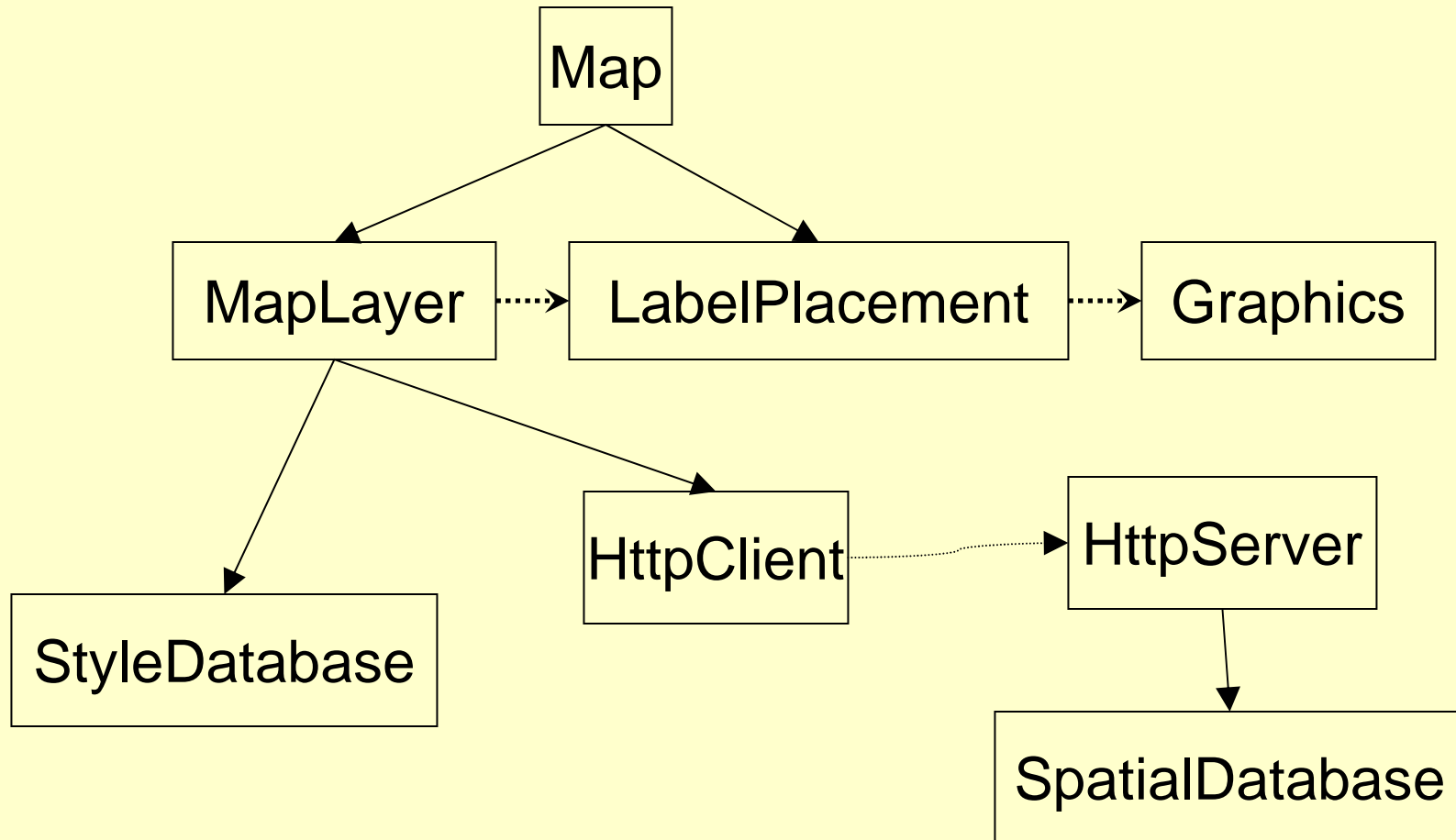
Efficiency

- Could have about 100,000 features/map
 - Why do all of this allocation and de-allocation
- Grouping helpful in other parts of the code
 - Graphics API's want groups
- SpatialDatabases often have them
- Created a class called FeatureGroup
 - Interface mimics a container of features
 - Also presents grouping interface

Standard Configuration



Research Configuration



Initial Results

- Forced to implement with partial design
- Created fair documentation
 - Use cases, class diagrams, sequence diagrams
 - Not updated during implementation
 - Lacked reasons for some crucial decisions
- Effort: 3 months design, 3 months coding
 - Management did not value design effort
- Design is iterative

Perceived Performance

- Compared well with previous system:
 - Half the previous draw time in general case
 - Much faster on detailed maps (2s vs. 30s)
 - New draw times were 0.5s-2s
- Management happy, but ...

Performance Issues

- Indications of inefficiency
 - Drawing or LabelPlacement should take time, but didn't
 - Execution time spread throughout code instead
- Profiler (Quantify) didn't show hot-spots
 - Stack too deep
 - Inline functions hide the code

My Next Project

- Evaluation of Curl
- What is Curl?
 - A Java-like programming language out of MIT
 - Optimized for downloading programs to web browsers
 - No byte-code
 - Code compiled as it is downloaded
 - For more information, see www.curl.com

Approach to the Evaluation

- Chose our project as a test case for Curl evaluation
- Decided to remove the interfaces
 - Performance of interfaces suspect anyway...
- Design didn't matter
 - Code would never be used
 - Tight timeframes

Initial Curl-Based System

- Ran in about 2-3s
 - Well, it's not C after all...
- The vendor (Curl) wasn't happy
 - So I took a business trip
- Led to the vendor
 - Choosing better API functions for drawing
 - Optimizing their APIs and compiler
- Result: draw time between 0.1s-0.2s
 - Zero perceived response time

Revisiting the Design

- 10x performance from Curl-based system
 - Zero response time compelling
- Dropped pieces of code to find the culprit
 - Aside: our good design made this easy
 - Improvement when LabelPlacement dropped
 - LabelPlacement used a container
- Optimized STL container usage
- Combined LabelPlacement and MapLayer
 - This breaks the design

Reflection

- Things I wish I had known:
 - Market forces / motivations of companies
 - Not to accept information at face value
 - How to balance SE vs. business tradeoffs
 - How to design for performance
- Did we drop the right parts of the design?
 - Software Engineering triage?
 - When do you just need to walk away?

Promoting Software Engineering

- What technical metrics do we need?
 - Are design-time metrics feasible?
- How do we express this to management?
 - Bridging technical metrics to the bottom line
- How do we evaluate design tradeoffs?
 - Good-design vs. good-performance tensions
 - Good-design vs. time-to-market tensions
- Need elastic (give & take) SE techniques

Goal: Understand Containers

- Is the container problem general?
 - Stack problems may have been a STL artifact
 - Inline functions make it hard to total time
 - Would automatic garbage collection be faster
 - Can STL provide useful hints to the profiler
- How do we create tools to find out?
 - Implementing a new system seems expensive
 - An accounting perspective: % of useful work?
 - The problem is API abuse looks useful

Conclusion

- Email:
 - gghartma@cs.cmu.edu
- Presentation
 - <http://www.cs.cmu.edu/~gghartma/SSSG-2002-1.pdf>